AN AUTOMATED MEDICAL HISTORY SYSTEM: EXPERIENCE OF THE LAHEY CLINIC FOUNDATION WITH COMPUTER-PROCESSED MEDICAL HISTORIES*

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John F. Fockart, Ph.D.
Ephraim R. McLean, Ph.D.
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John F. Rockart, Ph.D., is Associate Professor of Management, Alfred P. Sloan School of Management, Massachusetts Institute of Technology, Cambridge, Massachusetts, and Research Associate, Lahey Clinic Foundation, Boston, Massachusetts.

Ephraim R. McLean, Ph.D., is Assistant Professor of Information Systems, Graduate School of Management, University of California, Los Angeles, California.

Philip I. Hershberg, M.D., is Assistant Professor of Medicine, School of Public Health, Harvard University, Boston, Massachusetts, and Research Associate, Lahey Clinic Foundation, Boston, Massachusetts.

ABSTRACT

Since the late 1940's, efforts have been made to assist the physician in the time-consuming task of collecting medical history information. More recently, computer technology has been employed in the design of automated medical history systems. Researchers at a number of different locations have tried several approaches including the use of prepunched cards, keypunched or mark-sensed forms, and on-line terminal-based interview systems.

At the Lahey Clinic, an automated medical history system (AMHS) has been in operation since 1968 and as of the present time has been administered to over 30,000 patients. The system was designed to aid in patient scheduling, to assist the physician in his history taking, and to provide a data base for research studies.

The present Questionnaire is a 25-page booklet which is mailed to the patient at his home in advance of his appointment. The completed Questionnaire is mailed back to the Clinic where the booklet pages are optically scanned and processed by the computer. The resultant print-out is placed in the patient's medical record folder where it serves as the primary history document.

Although the Lahey system shares much in common with other computer-based history systems, it also has a number of distinctive features. These can briefly be summarized as follows:

1. The original development and operation of the AMHS was funded from the operating revenues of the Clinic.

2. It is a routine, integral part of the Clinic procedure and is administered to almost all new patients who come to the Clinic.

3. Because of the desire to use the results for advanced scheduling purposes, the Questionnaires are filled out by the patients at their homes.

4. The success of the system is due in large measure to the use of an interdisciplinary approach joining the skills of the physician, management scientist, and computer specialist.

5. By design, the AMIS is an evolutionary system. The present Questionnaire is the fourth version, and plans are already underway for the fifth version.

6. Accompanying these developmental activities is a strong commitment to continuing research and evaluation. Some of the studies which have already been conducted have dealt with physicians' attitudes, patients' attitudes, and content validity.

AN AUTOMATED MEDICAL HISTORY SYSTEM

Experience of the Lahey Clinic Foundation With Computer-Processed Medical Histories

John F. Rockart, Ph.D.
Ephraim R. McLean, Ph.D.
Philip I. Hershberg, M.D.

Of the many competing demands upon a physician's time, the taking of a patient's medical history is one of the most time consuming. Although it does provide an opportunity for the physician to establish good rapport with the patient, many physicians believe that it is not an altogether satisfactory means of gathering information for a number of reasons.

For one, there is never enough time. The physician's busy schedule does not allow him the luxury of exploring every aspect of the patient's physical and mental condition. In every patient interview a number of questions might be asked that would provide a more complete history, but there is simply not enough time for them. Fortunately, by training and by instinct, the experienced clinician is able to move quickly to the important facts of the patient's condition and rarely does any harm result from the few items of data that are missed. However, from the patient's standpoint, this inability of the physician to listen to all of his minor complaints and problems is somewhat disconcerting.

A second problem is the patient himself. Frequently he is

poorly prepared to be an effective historian. Family history is only vaguely remembered; drugs and medications are imperfectly recalled; and even for such simple questions as "How much coffee do you drink?" a few moments of mental calculations are necessary.

Also, there is the nature of the questions themselves. Questions of a highly personal or intimate nature can be embarrassing for the physician and patient alike. There is some evidence that valuable information is not elicited because of the physician's failure to ask certain questions or because of the patient's failure to respond frankly. Despite the physician's best efforts, the physician encounter can be a very stressful one for the patient, and this nervousness can be a barrier to good communication.[1]

It is not the intention of this article to suggest that there are easy solutions to these problems. However, techniques have been developed that offer great promise in assisting in this information-gathering process. Chief among these is the use of medical history questionnaires.

At first such questionnaires were merely a short list of printed questions with a space for the patient to mark his response. The physician would scan these responses and then proceed with his own questioning. With the advent of the computer, more sophisticated approaches have become possible. The responses can be fed into the machine and be edited, summarized, and printed out in an easy-to-read format. It is even possible to use a computer terminal to interrogate the patient directly

and then produce the resultant information on demand. A number of individuals have performed research on use of computer-processed medical histories. Although most of these efforts have been of an experimental nature, the results have been encouraging.

At the Lahey Clinic Foundation, a program for the computer processing of medical histories has been in operation since early 1968 and, while under continuing evaluation, is now an established part of the Clinic routine. As of the fall of 1971, over 30,000 patient-completed Questionnaires have been processed. This "production" aspect of the Clinic's automated medical history system--as opposed to a one-time test program--makes it a particularly interesting vehicle for study. Also, the Clinic's commitment to research and continually improving patient care has provided a receptive climate for an on-going appraisal of the system.

The Questionnaire itself has gone through three major revisions and the system has been the subject of several in-depth studies, including three on physician acceptance and use and two on patient attitudes. Although continuing improvements are anticipated, the system is now in a sufficiently mature state that it is possible to report on the results of the Clinic's experience. Also, distinctive aspects of the Lahey system, aside from its acceptance as a routine part of the Clinic procedure, merit attention. A discussion of these features, as well as a report on the results of the Clinic's experimental findings, will comprise the major part of the remainder of this paper.

Previous Work in the Field

The first questionnaire to come into general use was the Cornell Medical Index[2] (C.M.I.). Devised by Brodman in the late 1940's, it consists of a form containing 195 questions which is given to the patient immediately before the office visit. Further processing is not required, although some efforts have been made to introduce a computer-processed version.[3] The examining physician quickly scans the patient's responses and then proceeds with his own questioning. Since its introduction, the C.M.I. has undergone almost no changes in either its composition or in question wording. It continues to enjoy widespread popularity; it is estimated that more than 300,000 are administered annually.[4]

At special multiphasic health check-up laboratories within the Kaiser-Permanente Medical Centers in San Francisco and Oakland, California, Collen has used a medical history questionnaire for more than 20 years.[5,6] In its present form, it consists of two parts: a deck of 204 prepunched cards designed for review of systems information with a single yes-or-no question printed on each card, and a pencil-and-paper questionnaire for past history. For the first part, the patient indicates his response by dropping each card into the "yes" or "no" section of a divided letter box. The positive responses are then sorted and are available immediately for the physician's review. The responses on the questionnaire form are keypunched and are added to the patient's medical record later. Although not yet an integral part of the Kaiser Plan throughout California, this

multiphasic screening program, including the computer-processed medical history information, is recognized as one of the leaders in the field.

In a pioneering effort at the University of Wisconsin, Slack and his co-workers developed the first on-line computer-based medical history system.[7] Using a LINC laboratory computer, questions were presented to patients by means of a cathode ray tube screen. Patients keyed in their responses through a typewriter-like keyboard; and, at the end of the session, the results were summarized and printed out for the examining physician. The use of an on-line computer provided the ability to have extensive branching. The response to one question would determine, to a limited extent, the next question that was to be asked. In Slack's system, there were more than 500 questions, but the maximum number that could be asked of any one patient was 320. Although Slack has recently joined the staff of Beth Israel Hospital in Boston, this experimental work is still continuing at Wisconsin.

At the Mayo Clinic, Mayne et al. have explored a number of approaches to automated history taking.[1] The first system was, in many regards, the most sophisticated from a technical standpoint. Both photographic and cathode ray tube screens were used; the former to display color pictures of various parts of the body and the latter to present questions. The patient responded by means of a computer light-pen. By touching the CRT screen with the pen, the patient's answers were recorded. Throughout this

session at the computer terminal (slightly over an hour per patient), a full-time attendant was available to provide assistance. Although quite advanced technically, this system was also extremely expensive and only about four patients per day could be processed; it has since been discontinued.

A more recent development at Mayo has been the use of a three level pencil-and-paper questionnaire.[8,9] Recognizing both the benefits of multiple-level question branching (as was possible in the former on-line version) and the greater economies of computer batch processing, the system was designed to use the computer to tailor-make a more detailed second and, if necessary, third level questionnaire based upon the patient's responses to the preceding level. The first questionnaire has been tested on more than 3,000 patients and has been well received.

In evaluating various techniques of questionnaire administration, the Mayo group tried three approaches for presenting the questions: a deck of prepunched cards (as is used by Collen), a questionnaire that was manually keypunched, and another questionnaire that was designed to be optically scanned. They found that the latter method was the most satisfactory from an overall standpoint.

At the Massachusetts General Hospital, Grossman et al. have explored the use of on-line history taking.[10,11] Their work was done with the use of several Teletype terminals connected on-line to

a central computer. In the two years of operation at the Medical Diagnostic Center of the Massachusetts General Hospital, nearly 600 patients were processed, most of them on an outpatient basis. As with other on-line systems, the use of question branching causes the number of questions asked of a given patient to vary, in this case from as few as 90 to as many as 187. Patient acceptance was favorable.

Rationale for the Lahey Automated Medical History System

The Lahey Clinic Automated Medical History System (AMHS) differs from its computer-based predecessors in that the AMH Questionnaire was designed to be mailed to patients in advance of their Clinic visit. This was done so that the results of the Questionnaire could be used by the Clinic in the scheduling of patients to the appropriate specialists, and so that the AMH print-out could be available at the time of the patient's appointment to aid the physician in his history taking. These two reasons formed the primary justification for the development of the AMHS. A third reason was to establish a data base for research purposes.

Patient Scheduling

The Lahey Clinic is comprised of approximately 100 physicians, each practicing in 1 of 25 medical specialties. In its desire to keep patient waiting time to a minimum and to eliminate as much as is practicable the need for multiple Clinic visits, the Lahey Clinic makes every effort to schedule both the primary and secondary appointments in advance of the patient's arrival. This approach is in contrast to other large clinics where no special-

ist appointments are made until after the patient arrives at the clinic and has been seen by the primary physician.

In order for the Lahey appointment office to make these appointments in advance, the appointment secretaries must try to obtain some information from the patients as to the nature of their complaints either from the contents of their letters or from short telephone conversations. Despite the difficulty of this task and the fact that the secretaries have no special medical training, their years of experience, coupled with written guidelines, have enabled this advanced scheduling system to be reasonably successful. However, cancellations and "work-ins" are inevitable and the Clinic has long searched for ways whereby the procedure could be improved. The AMH Questionnaire provided the potential for such an improvement. It was felt that if the results of the computer-processed Questionnaires could be made available to the appointment secretaries in a convenient form, they would have much better information upon which to base their decision as to the most appropriate physician for the patient to see. As of this time, the use of the AMHS for patient scheduling is still on a trial basis, but the results are encouraging.[12]

Aid to the Physician

Although the preceding benefit, that of scheduling assistance, was the first reason advanced in support of the AMHS's development, the second benefit, that of providing aid to the physician in his own history taking, has been given increasing attention by the Clinic. The development of the system was particularly timely from the physicians' point of view because

at about the same time it was being introduced, the number of residents available to assist in work-ups was being substantially reduced. Thus many physicians were more willing to give the system a try than might otherwise have been the case.

As might be expected, the physicians have used the Questionnaire in different ways and have thus derived differing benefits from its presence in the medical record. Some have realized a distinct time saving, while others have used the same amount of time as formerly but have been able to make a more complete evaluation of the patient. A few, of course, feel that the AMHS has not been helpful to them at all. In a recent survey of the physicians' attitudes toward the AMHS, the following benefits were each noted by a large number of physicians with regard to the system:

1. Fewer questions need be asked of the patient, especially on family and social history.
2. Less writing is necessary; also, those work-ups performed by other Clinic physicians are easier to read.
3. The automated medical history provides a good starting point for more detailed questioning; it gives the physician a "head start."
4. The history is "more complete."
5. The patient, having been forced to think about his problems beforehand, becomes a better historian.
6. The history is helpful in bringing to light problems that lie in areas other than the physician's own specialty.

7. Finally, even those physicians who wish to take their own histories entirely have suggested that it does provide "a check on my own history."

Research

The development of the AMHS has provided a rich opportunity to explore the fundamental process of medical history questioning and its role in the determination of a diagnosis. Several projects have been undertaken which attempt to assess question validity and the role of individual questions in contributing to a final diagnosis.[13,14]

Because of the anticipated use of the Questionnaire to assist in patient scheduling, a continuing study is being made of the value of each question or series of questions in determining which specialist is most appropriate for the patient to see. The Questionnaire responses of several thousand patients have been correlated with the final diagnoses that were subsequently made by Clinic physicians in order to discover which questions are most valuable in indicating a particular specialty. For example, preliminary results indicate that patients who respond positively to the question "Do you find it necessary to prop yourself up (with extra pillows or in a chair) in order to sleep?" are more likely to have allergic disease (for example, stuffy noses) rather than cardiologic disease despite the classic medical thesis that orthopnea implies heart disease. It is hoped that objective statistical analysis can replace the present subjective criteria that are being used in question selection.

In another study, focusing primarily on cardiologic conditions, matched (by age and sex) sets of patients have been established, one group having one of several cardiac conditions and the other group being free from such problems. Using statistical techniques, the responses of each group to certain questions are being analyzed to determine those questions--in association with particular laboratory tests--which are most useful in screening for cardiac disease.

A recent study has looked at the sensitivity and specificity of 20 questions drawn from the AMH Questionnaire.[15] While some questions proved to have a high correlation with the diagnoses they were designed to suggest (e.g., joint and bone pains), other questions were found to be very poor predictors of diagnoses. Such well-established questions as recent onset of orthopnea, prominent eyes, and incidence of chest pain which increases with swallowing had very low correspondence (less than 7 percent) with the supposedly related conditions.

A final project, still in the planning stage, is concerned with whether it is possible to use some of the data from the Questionnaire to determine whether certain laboratory tests, roentgenograms, cardiologic studies, and other tests should be performed. At present, no tests are ordered until after the patient has had his first appointment with the physician. It is possible, however, that a few basic tests can be performed prior to this first visit. In this way the physician would have more complete information available to guide him in further

evaluation of the patient's condition.

Description of the AMHS

Since the first Questionnaire was administered in early 1968, three major revisions have been made; version V, the fourth revision, is now under active development. The first two versions, drawn largely from the questions on the Massachusetts General Hospital on-line questionnaire, were experimental in nature and were administered on a limited basis. Version III was the first full-scale test and was administered to about 12,000 patients. It contained 392 "yes" and "no" questions and a free-form answer sheet for chief complaint, drugs, and so forth. The code numbers of the positive responses were keypunched and these numbers were matched by the computer with a response-symptom file. The resultant print-out was a list of these symptoms. Little editing was possible and only a few of the questions involved the use of any qualifiers, that is, additional questions which helped determine the duration, severity, or exact location of a complaint. In addition, the fact that each Questionnaire had to be keypunched manually severely limited the number of patients who could be processed on a daily basis.

The present version of the AMH Questionnaire (version IV) was first distributed to patients in the spring of 1970 and incorporates the experience of the three preceding versions. In its present form, the AMHS operates as follows:

When a new patient contacts the Clinic for an appointment, one of the secretaries finds the first available time in the

appropriate physicians' schedules and makes the necessary appointments. Preregistration material is then mailed to the patient; and, if the appointment is more than ten days away, an AMI Questionnaire is also sent in the same envelope. If there are less than ten days, there is usually insufficient time to assure the return of the Questionnaire in time for it to be processed and inserted into the patient's medical record. More than 85 percent of the patients who receive the Questionnaire complete it and return it to the Clinic.

The Questionnaire itself consists of a 25-page booklet with 160 questions covering family and social history, former illnesses, and a review of systems. However, many of the questions have several parts, and a better measure of its true length is the number of possible responses, of which there are 619. Two sample pages are shown in Figure 1. These pages illustrate how question branching is achieved; if the answer to question 48 is negative, the next several questions can be skipped. Most patients finish the entire Questionnaire in less than an hour's time. In addition to these multiple-response questions, the first page of the booklet also contains a space for the patient to describe, in his own words, his chief complaint and any past hospitalizations, allergic drug reactions, and medications he is currently taking. This open-ended section has a pressure-sensitive adhesive backing; it is attached to the top portion of the print-out after the computer has completed the processing of the other responses (Fig. 2).

Upon being returned to the Clinic, the Questionnaires are read by an optical scanner. The use of mark-sense forms was approached with some misgivings since these forms had to be mailed, filled out by patients at home, returned to the Clinic, and still be in condition to be optically scanned. However, use of mark-sense forms has proved to be quite satisfactory and less than 5 percent require any manual intervention to insure successful processing.

When the responses are read into the computer, an extensive amount of editing is performed at the same time the answers are being converted into medical terminology. The introduction of editing was done with two goals in mind: to eliminate logical inconsistencies and to reduce the amount of "over-reporting." The first objective is more straightforward than the second. For instance, if a patient has indicated that he does not have headaches, but then proceeds to answer in the affirmative all the subsequent questions concerning frequency, duration, severity, and so forth of headaches, he has obviously mismarked the lead question. Therefore in order for it to be consistent with his subsequent responses, "HEADACHES" is printed out even though it is marked "no." Another example concerns the patient who reports stomach pains both daily and weekly. Obviously the first subsumes the second and therefore only "DAILY" is printed.

A criticism that is sometimes made of automated medical history systems is that they are not discerning enough; there are too many false positives or reporting of details that are

not significant. This "over-reporting" is a concern of the Lahey physicians and efforts have been made to suppress the printing of certain qualifying responses that add little value to the history. For example, a patient reporting "abdominal pain" which occurs "a few times a year" and is "crampy" with an onset "a few minutes after eating" would have the last two qualifiers omitted from his print-out. On the other hand, if he had indicated that the pain occurred "daily," all of the qualifiers would be printed.

Since only positive responses are printed, the physician must be able to rely on the absence of a response as indicating that the patient has answered "no." If a patient omits a question or series of questions, this is brought to the doctor's attention by an "UNANSWERED" notation followed by the symptom that is associated with the missed question. However, if several questions are missed, the print-out could be filled with these "UNANSWERED" notations. Therefore, within each section of the review of systems, if more than two questions are unanswered, the printing of "UNANSWERED" is suppressed and a statement at the bottom of the section states "SOME QUESTIONS UNANSWERED." With the development of version V, this editing capability is to be expanded even further.

At the same time that the responses are being edited, summarized, and printed, the computer is also calculating scores for scheduling purposes for each of the major Clinic specialties. It is important to note that the purpose of these scores is <u>not</u> to attempt to determine a preliminary diagnosis but merely to determine in which medical specialty the patient's problem is

most likely to lie.

On the day of the patient's scheduled appointment, a medical record folder is prepared by the new patient department, including the AMH print-out and the statement of the patient's chief complaint. Where formerly this print-out was in addition to the regular Clinic medical history form and review of systems checklist, the AMH print-out is now the only document in the record pertaining to the medical history and review of systems. When the physician interviews the patient, he makes all of his notations directly on the print-out. Frequently this is merely a matter of circling, underlining, crossing out the printed entry, or making a short additional comment (Fig. 3). The fact that the AMHS is now an integral part of the clinic procedure has done much to increase its acceptance by the staff physicians--it is no longer a time-consuming "extra." This daily exposure to the AMHS responses by a large number of different Clinic physicians provides the best mechanism possible for the continual evaluation and improvement of the system.

Physician Acceptance

Unquestionably a major factor in the success of the Lahey AMHS is the leadership taken by the Clinic staff in its development. George O. Bell, M.D., the Clinic's former Chairman of the Department of Internal Medicine, played a central role in the introduction of the system and served as Chairman of the automated Medical History Questionnaire Committee--the Clinic physician group who guided development of the Questionnaire.

However, contributions to the development of the system have not been limited to these few physicians. More than a third of the Clinic staff members have made suggestions concerning the content of the Questionnaire, the wording of the questions, and the formatting of the print-out.

In 1969, and then again in 1970, two major studies were conducted in order to determine the Clinic physicians' attitudes toward the AMHS. In the 1969 study, 47 Clinic physicians (all of the Clinic specialties except surgery) were interviewed for approximately one hour each by means of both structured and open-ended questions.[16] By combining the answers to five of these questions such as "How useful are the print-outs to you?," "What is your attitude toward the medical history system?," and "What is your recommendation as to the number of Clinic patients who should receive the medical history Questionnaire?," a composite measure of each physician's overall acceptance and use of the AMHS was developed. At one end of the scale, the responses were "Very unfavorable," "Almost useless," and "Discontinue the system," while at the other end the responses were "Very favorable," "Exceptionally useful," "All patients should receive it," and "The Questionnaire serves as the primary basis for the patient history and review of systems."

In addition to these questions, the physicians were also asked for any suggestions or possible improvements that could be made to the system. Based upon their suggestions, a number of changes were made and the present version of the Questionnaire (version IV) was inaugurated in early 1970.

In the summer of 1970, one year after the first attitude measurement, a second study was conducted, this time with 73 of the Clinic staff participating. In this second study, the surgical specialties were also interviewed, even though they do not perform primary work-ups. The same series of questions were used in order to insure comparability of results. In Figure 4, the results of this second study are shown. As can be seen, almost 75 percent of the physicians are favorable and deem the system useful. Some 30 percent of the responses are in the "Very favorable" region. No significant difference could be found in acceptance and use between surgeons and other physicians.

In order to compare these results with the preceding year, the data for 1969 and 1970 are plotted together in Figure 5. Percentage figures rather than absolute numbers are used in order to compensate for the differences in sample size. The fact that the curve for 1970 is everywhere above the 1969 line clearly illustrates the positive shift in attitudes of the Clinic physicians. However, it would be misleading to give the impression that all physicians became more favorable after an additional year's exposure to the system. Many, of course, did become more favorably inclined; others, though, felt that the AMIS was a disappointment and did not live up to its early promise. In Figure 6, the 41 physicians who participated in both studies are graphed according to the amount of change in their attitude. As can be seen, only 6 had more than 4 percent decrease, while 16 had increases of this amount in their attitude toward the AMIS.

One other question that was asked in both studies concerned the ability of the AMH print-out to save the physician time in his interviewing of the patient. The reported time savings ranged from none to over 15 minutes, with 44.7 percent of the physicians in 1969 reporting at least some time savings and 58.6 percent of the physicians in 1970 reporting their belief that the AMHS allowed time savings--an increase of over 30 percent.*

Patient Attitudes

A concern that has been raised by some physicians is that although physicians may like the assistance that computer-based medical history systems afford them, patients may not. A review of the experience of other researchers shows that there is little evidence to support this concern.[1,2,7,11] In our case, in a study of 2,000 patients who had received the Lahey Questionnaire,[17] only 6 patients registered unfavorable reactions. About three quarters made no comments at all and the remaining 477 were mildly to strongly favorable. In particular, many patients noted that they preferred filling out the Questionnaires in the quiet of their homes where they were amid familiar surroundings and therefore less nervous. Also, family records could be consulted, and the names of current drugs and medications could be accurately recorded. Some even stated that the mere act of completing the Questionnaire was in some way reassuring.

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*More rigorous measures of time saving will be developed in the future. But, if only as an expression of attitude toward the questionnaire, these time-saving figures are interesting.

Content Validity of the AMHS

In attempting to measure the accuracy of an automated history gathering technique, the prime difficulty is that of defining a standard against which to compare it. The obvious choice is to compare the computer-produced history with one that has been prepared by the physician who has actually worked-up the patient. This approach has been used by other researchers, but it is not without problems. As Feinstein has pointed out, the type and amount of patient data that are collected by different physicians can be highly variable.[18] Because of differences in physician training, personal characteristics, and time available to see each patient, the histories taken by two different physicians of the same patient can contain many differing entries. Therefore, it is not surprising that differences are also found when comparing an automated medical history with a physician's report.

Generally, the medical history questionnaires report significantly more findings than are recorded by physicians.[1,2,11] In addition, a number of false positives and false negatives have been found to occur. For example, Grossman et al. found an average of two false positives (findings recorded by the automated medical history but not by the physician) and three false negatives (items recorded as negative by the automated medical history but positive by the physician) in each automated medical history examined.[11]

At the Lahey Clinic, this topic is the subject of continuing investigation. In a recent study of 48 patient records, a com-

parison was made between the AMH print-out and the histories taken by physicians who had not had the opportunity to see the print-out. (This was because the Questionnaires arrived too late for processing and inclusion in the medical record.) The results are shown in Table 1. The amount of "over-reporting" is quite apparent. However, this extra information generally falls into one of three categories: (1) social history (educational background, amount of exercise, tobacco and alcohol intake, and so forth); (2) mental condition ("depressed," "nervous," "excessive irritability," "frequent spells of loneliness"); and (3) qualifying details concerning major symptoms (chest pains occurring "a few times a year," "after exertion," "relieved by resting," and so forth). In the opinion of the Clinic's AMHQ Committee, the small penalty paid in terms of increased reading time is more than offset by the improved picture of the patient's condition.

A second study at the Clinic focused exclusively on false positives. In this case, the AMH print-outs that had been marked up by physicians as they conducted their own patient interviews were used as the basis of study. Naturally, different physicians use the print-out in different ways; but one usual procedure is for the physician to cross out those items which the patient denies if and when the question is asked again during the work-up. In this way false positives are automatically highlighted not by a researcher attempting to compare and reconstruct the "true" situation but by the practicing clinician as he routinely takes the patient's history.

In a review of 252 medical records, drawn from among the patients of 30 Clinic physicians, a total of 306 false positives was found. This is an average of 1.2 per history. Certain questions, however, led to significantly high rates of false positives (0.01 level on a Chi square test), suggesting that perhaps the questions were vague or misleading in their wording. As a result, nine questions have been modified in order to improve their validity. In addition, a small group of physicians, who appear to rigorously reask most of the questions of the patient, indicated a number of false positives significantly greater than their colleagues.

One conclusion that can be drawn from the preceding is that the usual standard of measurement--the comparison of an automated medical history with an independently performed physician history--leaves much to be desired. In order to evaluate even a few histories, an inordinate amount of extra work is necessary. When the automated history is used as an integral part of the physician's history taking procedure, however, it becomes possible to verify its accuracy on a continuing basis, and the process of gathering data for research purposes becomes far simpler.

Discussion and Summary

Although the Lahey AMHS shares a number of features in common with other automated medical history systems and acknowledges its debt to these other efforts, a number of unique features of the Lahey System merit special attention.

The Lahey Questionnaire is mailed to patients in advance of their Clinic visit in order that patients may have the advantage

of filling out the Questionnaire in their own home. In addition, the results of the AMHS can be used as an aid in appointment scheduling. Another benefit of this approach is that the history print-out is processed and ready for the physician's review prior to the first meeting with the patient and this processing is done on an economical batch basis rather than with more expensive on-line computer equipment.

This mailing procedure does create some problems, but there have also been some unexpected benefits. On the cost side, there are, naturally, the expenses of postage, special return envelopes, and clerical handling. Also, there are no attendants for patients to turn to if they have problems or questions concerning the Questionnaire. The introductory letter and the Questionnaire instructions must stand alone; they must both convince the patient that completing the Questionnaire is important and give him all the necessary information so that it is clear to him what he must do. This requirement, albeit a demanding one, has proved to be beneficial in establishing a high standard for Questionnaire construction. Because the Questionnaire is filled out in the familiar, unhurried atmosphere of the home where the patient is able to consult family records, drug labels, and other pertinent files, the resultant history is felt to be more accurate than it might be otherwise.

Although the central role of the Clinic staff in the development of the AMHS has been described, one aspect of their commitment has not been mentioned, namely, the source of financial support. Throughout the first two years of the existence of the

AMHS, the support for both the development work and the operating expenses came entirely from the operating revenues of the Clinic. It has only been in the last year that governmental funds have been used to pay for any of this work.

This commitment has also led to the system being established as an integral part of the Clinic procedure. All new patients who come to the Lahey Clinic--for whatever reason--are sent the Questionnaire, providing there is sufficient time for mailing and processing. The AMHS print-out is now the sole document in the medical record relating to the patient's medical history and review of systems; all physicians' notations are made directly on these sheets. Consideration is now being given to extending its administration, perhaps in a modified form, to previously registered (returning) Clinic patients as well.

Throughout the life of the AMHS project, a significant number of the Clinic physicians have been involved in the development, evaluation, and improvement of the system. Our research data suggest that this participation has been a major factor in the high level of acceptance that the system enjoys. A part of this success is also due to the other skills that were brought to bear on the project, particularly those of the management scientist and the computer specialist. The ability of the AMHS to perform various types of editing and to analyze and organize the responses in terms of medical specialties are examples of the former. The contributions of computer technology to process, rapidly and accurately, large numbers of Questionnaires are evidence of the latter. The importance of using interdisciplinary

approaches to problem solving and system design is being increasingly stressed today. The Lahey Clinic Automated Medical History System is an example of such a team effort.

Indexing Terms

Lahey Clinic Automated Medical History System (AMHS)

Computer technology

Lahey Clinic Questionnaires

Table 1

Comparison of Positive Responses as Recorded by the AMIS and by the Lahey Physicians

Positive Responses	Total (for 48 Patients)	Average per Patient
Reported by AMIS	2,802	58.4
Confirmed by physicians' report	1,037	22.6

Legends

Fig. 1. A and B, Sample pages of Lahey Clinic AMHS Questionnaire.

Fig. 2. Sample print-out of AMHS Questionnaire (with chief complaint section attached).

Fig. 3. A,B,C, and D, AMHS print-out. Comments are those of examining physician.

Fig. 4. Acceptance and use of the AMHS by Lahey Clinic physicians. Data for 1970; N = 73.

Fig. 5. Acceptance and use of AMHS by Lahey Clinic physicians. Plotted cumulatively for 1969 and 1970.

Fig. 6. Amount of change in acceptance and use of AMHS by Lahey Clinic physicians between 1969 and 1970; N = 41.

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5. B. DO YOU STILL GET PERIODS OF WHEEZING? . . . . . Yes 374 No

6. HAVE YOU HAD ANY OF THE FOLLOWING CONDITIONS IN THE LAST 2 YEARS?

Frequent night sweats that completely drench your clothes 375
Frequent sweats, other than at night, which occur when you are not working or exerting yourself 376
Pleurisy 377
Hay fever or frequent sneezing spells 378
Frequent bronchitis 379
Bronchial asthma 380
Emphysema 381
Pneumonia 382
A chest x-ray that was reported as being abnormal 383

7. HAVE YOU EVER HAD ANY OF THE FOLLOWING?

Tuberculosis 384
Close contact with people who had tuberculosis (including anyone in your family) 385
A positive tuberculosis skin test 386

8. ARE YOU BOTHERED BY PAIN, DISCOMFORT, TIGHTNESS, OR PRESSURE IN YOUR CHEST? . . . . . Yes 401 No

If no, go to Question 49.

A. HOW WOULD YOU DESCRIBE THIS FEELING? (Mark only one)

A slight discomfort only 402
Some pain 403
Severe pain 404

B. HOW OFTEN DOES IT OCCUR? (Mark only one)

A few times a year 405
Once a month 406
Every 2 or 3 weeks 407
More than once a week 408
Every day 409

C. WHERE IS THE CHEST PAIN OR DISCOMFORT LOCATED? (Mark only one)

In the middle of your chest, under the breast bone 410
On the left side only 411
On the right side only 412
On both sides 413

D. IS THE PAIN OR DISCOMFORT MADE WORSE BY BREATHING DEEPLY? . . . . . Yes 414 No

E. WHEN DOES THIS PAIN OR DISCOMFORT COME ON?

After eating a large meal 415
Upon becoming angry or excited 416
When doing strenuous work or walking rapidly 417
When turning from side-to-side, leaning forward, or lying down 418

F. IS THE PAIN OR DISCOMFORT MADE WORSE BY SWALLOWING? . . . Yes 419 No

G. IS THE PAIN OR DISCOMFORT RELIEVED BY RESTING? . . . . . Yes 420 No

H. IF THE PAIN OR DISCOMFORT IS RELIEVED BY RESTING, HOW LONG DOES IT TAKE TO GO AWAY? (Mark only one)

Less than a minute 421
Less than 5 minutes 422
5 to 30 minutes 423
More than 30 minutes 424

I. DO YOU NEED TO TAKE MEDICINE, SUCH AS NITROGLYCERINE, TO RELIEVE THE PAIN? . . . . . Yes 425 No

J. DO YOU GET POUNDING, SKIPPING, THUMPING, OR RACING OF YOUR HEART (palpitations and/or fluttering) WHILE YOU ARE AT REST? . . . . . Yes 426 No

K. DO YOU FIND IT NECESSARY TO PROP YOURSELF UP (with extra pillows or in a chair) IN ORDER TO SLEEP? . . . . . Yes 427 No

IF SO, FOR HOW LONG HAVE YOU SLEPT PROPPED UP?

Less than a month 428
A few months 429
About a year 430
More than a year 431

L. WHEN YOU WAKE UP IN THE MORNING, ARE YOUR FEET OR ANKLES SWOLLEN? . . . . . Yes 432 No

M. ARE YOU BOTHERED BY CONTINUOUS SWELLING OF YOUR FEET OR ANKLES DURING THE DAY? . . . . . Yes 433 No

N. DO YOU CONSISTENTLY GET PAINS IN YOUR CALVES OR LOWER LEGS WHEN YOU WALK A BLOCK OR SO? . . . . . Yes 434 No

If no, go to Question 54.

A. DO THESE PAINS MAKE YOU STOP WALKING? . . . . . Yes 435 No

B. DO THESE PAINS GO AWAY AFTER A SHORT REST (less than 10 minutes)? . . . . . Yes 436 No

34-50P PATIENT, NAME OF AGE - 70 SEX - M MO 1/70 10/26/71

ME Patient Name

JR CHIEF MEDICAL PROBLEM (the reason your coming to the Lahey Clinic): Dizzy Spells

3. TODAY'S DATE: Oct 13, 1971

ME OR TYPE OF SPECIALIST, IF ANY, GESTED BY YOUR DOCTOR: None.

MES OF DRUGS OR MEDICINES TO WHICH YOU HAVE A BAD OR LERGIC REACTION: None

6. NAMES OF DRUGS OR MEDICINES YOU ARE NOW TAKING (including aspirin, laxatives, vitamins, or tranquilizers): Aspirin.

7. HOSPITALIZATIONS: 1971 Year — Dizzy Spells. Reason

FAMILY HISTORY

HEART ATTACK OR ANGINA- CANCER-
HYPERTENSION- KIDNEY DISEASE-
TUBERCULOSIS- STROKE-
SKIN DISEASE- FATHER DIED AT 75 OF CANCER.
MOTHER DIED AT 89 OF HEART DISEASE. 4 OR MORE SIBLINGS.
4 OR MORE SIBLING DEATHS, CAUSES-

TOBACCO-ALCOHOL
COFFEE-TEA
CHANGE-GAIN/LOSS
EXERCISE-DIET
WORK- HRS
SLEEP- HRS
TRAVEL
FEVER-CHILLS
SWEATS

MARRIED. 4 OR MORE CHILDREN. SOME COLLEGE. RETIRED.
WORKS 20 OR LESS HRS/WK. HX PIPE SMOKING.
HX CIGAR SMOKING.
SMOKES 3 OR MORE CIGARS/DAY. SMOKES PIPE AT PRESENT.
NO ALCOHOL INTAKE. WT GAIN UNDER 10 LBS/PAST 6 MOS.
1-3 CUPS COFFEE/DAY. NO TEA INTAKE.
MINIMAL EXERCISE PROGRAM. NO PHYSICAL IN LAST 2 YRS.

VISION-EYES
HEARING-EARS
NOSE-THROAT
TEETH-GUMS
TONGUE
NECK

BLURRED VISION IN PAST YR.
BRIGHT LIGHT DISCOMFORT/PAST YR. VISION CHANGE/PAST YR.
SLIGHT DEAFNESS.

COUGH-WHEEZE
SPUTUM-HEMOPTYSIS
PLEURISY

CHEST PAIN-PALPIT.
EDEMA-LEG PAIN
DYSPNEA-ORTHOPNEA

VARICOSE VEINS. HX HEART MURMUR.

PETITE-FOOD INTOL.
ALLOWING-HEARTBURN
ABDOMINAL PAIN
NAUSEA-VOMITING
BELCHING-FLATUS
BOWELS- FREQ., CHAR.

CONSTIPATION. EXCESSIVE FLATUS.

TAL PAIN-BLEEDING AXATIVES-JAUNDICE	
BACKACHE INTS-MUSCLE ACHES	JOINT STIFFNESS. HX ARTHRITIS.
DYSURIA-STONES REQUENCY-NOCTURIA REAM-INCONTINENCE PYURIA-HEMATURIA	URINATES 4-7 TIMES/DAY. HX PROSTATITIS.
ECCHYMOSES	
GLANDS HEAT/COLD INTOL.	
ALLERGIES HAIR-NAILS SKIN-ITCHING	
HEADACHE IZZINESS-FAINTING SORY DISTURBANCES TREMOR-SEIZURES MEMORY LOSS WEAKNESS-FATIGUE ENSION-DEPRESSION INSOMNIA	SEVERE DIZZY SPELLS, SEVERAL TIMES/MO, FOR 1-2 MINS. ASSOC SPINNING SENSATION. ASSOC STAGGERING. SLEEPS 7-8 HRS/NIGHT. IRRESISTIBLE URGE TO SLEEP. MEMORY LOSS IN PAST YR. DEPRESSED. NERVOUS. EXCESSIVE IRRITABILITY. FREQ SPELLS OF LONELINESS.
SES- ONSET LMP DAYS-FLOW DAYS PAIN INNORR-METRORRHAGIA VAGINAL DISCHARGE G GRAV PARA AB COMPLICATIONS FLASHES	

FORMER ILLNESSES CHECKLIST	0 RHEUMATIC DISEASE	0 TBC	0 THROMBOEMBOLISM
	X HEART DISEASE	0 ANEMIA	0 THYROID DISEASE
	0 HIGH BLOOD PRESS.	0 HIVES-ECZEMA 0	0 VENEREAL DISEASE
	0 BLOOD TRANSFUSION	0 GI BLEEDING	0 TUMOR
	0 PULMONARY DISEASE	0 ULCER	0 NEUROPSYCH.
	0 ASTHMA-HAY FEVER 0	0 DIABETES	OTHER

RESEARCH DATA- NR 15 PS 13 CA 8 PM 11 TR 5

AGE - 19 SEX - M MO 1/70 04/01/70

E

4 CHIEF MEDICAL PROBLEM (the reason our coming to the Lahey Clinic):

3. TODAY'S DATE: 3-[illegible]-70

ERVES FOR TREMBLE OF Hands

E OR TYPE OF SPECIALIST, IF ANY, ESTED BY YOUR DOCTOR:

ES OF DRUGS OR MEDICINES TO WHICH YOU HAVE A BAD OR ERGIC REACTION: None

6. NAMES OF DRUGS OR MEDICINES YOU ARE NOW TAKING (Including aspirin, laxatives, vitamins, or tranquillizers):

Tranquilizers
@ NARAME ℈ X3
@ AKINETON ℈ X2

7. HOSPITALIZATIONS:

Year	Reason
1970	NERVES

FAMILY HISTORY

HEART ATTACK OR ANGINA- Grandfather, CANCER- ? unknown
HYPERTENSION- Grandfather DIABETES- Grandfather,
STROKE- Uncle MUSCLE DISEASE- ? unknown
unknown ? → THYROID DISEASE OR GOITER-
NERVOUS STOMACH- 1 SIBLING.
Both parents have gone other
Brother paranoid + blind - why unknown

+TOBACCO-ALCOHOL
/-COFFEE-TEA
CHANGE-GAIN/LOSS
EXERCISE-DIET
WORK- HRS
SLEEP- HRS
TRAVEL
FEVER-CHILLS
SWEATS

PT SINGLE. ATTENDED HIGH SCHOOL. UNEMPLOYED.
HX CIGARETTE SMOKING FOR LESS THAN 5 YRS. 1-2 PACKS/DA
PT REPORTS NO ALCOHOL INTAKE.
PT UNAWARE OF ANY WT CHANGE. FREQ USE OF TRANQUILIZERS
PI + HX NARCOTICS USE. DRINKS UNDER 1 CUP COFFEE/DAY.
= DENIES TEA INTAKE. MILD EXERCISE OBTAINED.
FAMILY CONFLICT REPORTED. NO PHYSICAL WITHIN LAST 2 YR
↳ Arguments ↑ per wife re: drug use.

VISION-EYES
HEARING-EARS
NOSE-THROAT
TEETH-GUMS
TONGUE
NECK

POOR TEETH NOTED - need dentures, many caries
clean tongue white deposits

COUGH-WHEEZE
SPUTUM-HEMOPTYSIS
PLEURISY

PRODUCES SPUTUM. WHEEZING NOTED IN PAST 2 YRS,
ONSET 3 MOS-2 YRS AGO, RES ~~PAD TEST~~.
with bronchitis 6 mos ago

CHEST PAIN-PALPIT.
ECEMA-LEG PAIN
DYSPNEA-ORTHOPNEA

when taking drugs only - can't c "nervous"

ETITE-FOOD INTOL.
ALLOWING-HEARTBURN
ABDOMINAL PAIN
NAUSEA-VOMITING
BELCHING-FLATUS
OLS- FREQ. ? CHAR.
AL PAIN-BLEEDING

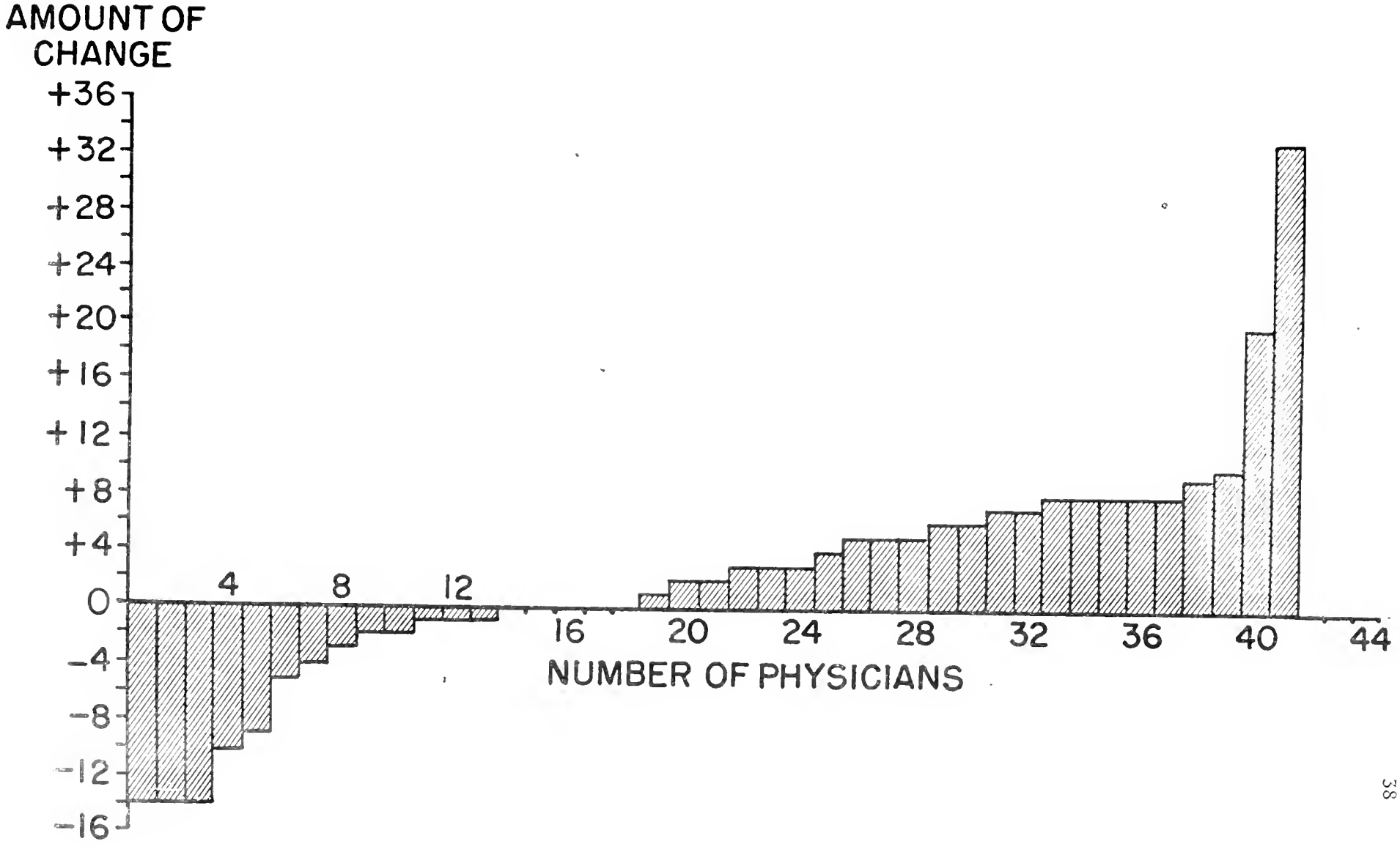
~~PT NOTES ABDOMINAL PAIN, SLIGHT, LESS THAN ONCE/MO.~~,
NOTES STRAINING AT STOOL. STOOL USUALLY VERY HARD.

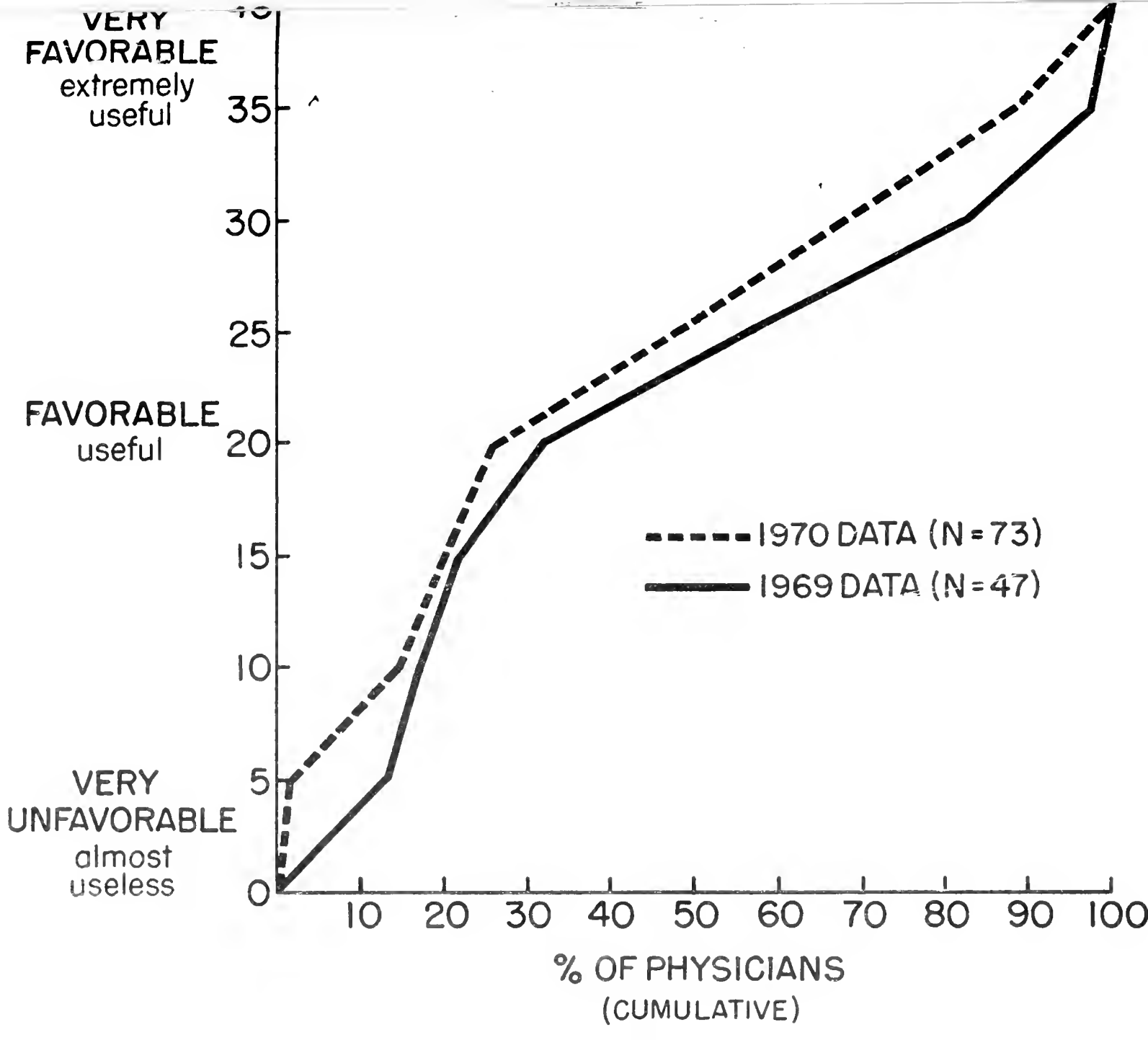
low back & r? hip — in ?

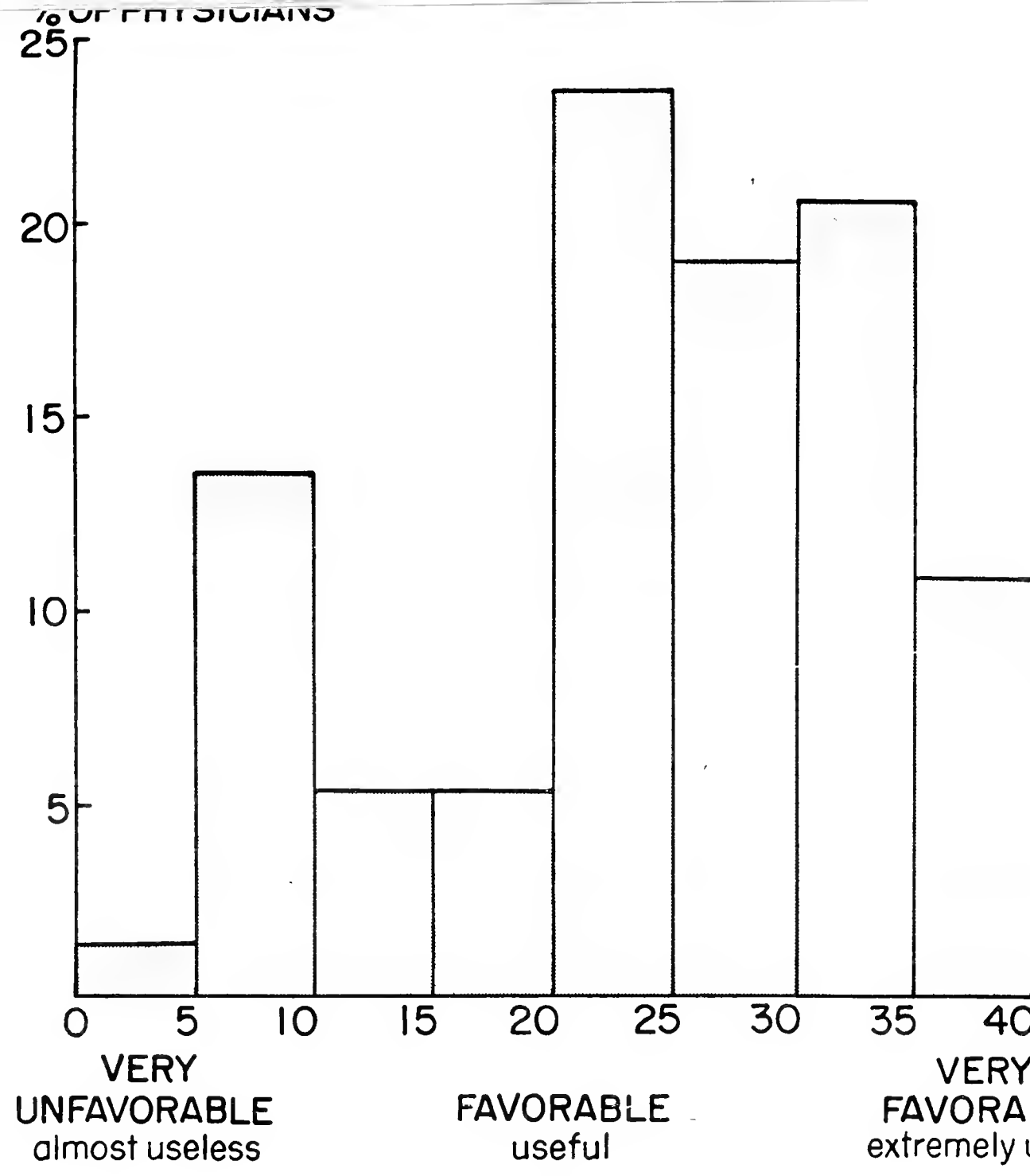
BACKACHE JOINTS-MUSCLE ACHES	NOTES JOINT STIFFNESS. HX ARTHRITIS. NOTES JOINT/BONE PAIN, INTERMITTENT, RELIEVED BY WALKING, RELIEVED BY A.S.A.
DYSURIA-STONES FREQUENCY-NOCTURIA STREAM-INCONTINENCE PYURIA-HEMATURIA	URINATES OVER 7 TIMES/DAY. NOCTURIA, 2-3 TIMES/NIGHT, FOR MORE THAN 1 YR. HX HERNIA. no recent change no dribbling some urgency —
ECCHYMOSES	
GLANDS HEAT/COLD INTOL.	
ALLERGIES HAIR-NAILS SKIN-ITCHING	
HEADACHE DIZZINESS-FAINTING VISUAL DISTURBANCES TREMOR-SEIZURES MEMORY LOSS WEAKNESS-FATIGUE TENSION-DEPRESSION INSOMNIA	QX-NOTES INSOMNIA, AND EARLY RISING. SLEEPS 4-6 HRS/NIGHT. PROB NARCOLEPSY. Rests well — MEMORY LOSS IN PAST YR. V.V, all life — Phlebitis 2X in left leg — last time 10 - 15 yrs ago —
MENSES ONSET LMP DAYS-FLOW DAYS PAIN MENORR-METRORRHAGIA VAGINAL DISCHARGE PREG GRAV PARA AB COMPLICATIONS FLASHES	

FORMER ILLNESSES CHECKLIST			
	0 RHEUMATIC DISEASE	0 TBC	X THROMBOEMBOLIS
	X HEART DISEASE	0 ANEMIA	0 THYROID DISEAS
	X HIGH BLOOD PRESS.	0 HIVES-ECZEMA 0	0 VENEREAL DISEA
0 problem OK now	0 BLOOD TRANSFUSION	0 GI BLEEDING	0 TUMOR
	0 PULMONARY DISEASE	0 ULCER	0 NEUROPSYCH.
	0 ASTHMA-HAY FEVER 0	0 DIABETES	OTHER

SCHED. SPECIALTIES-					
CARDIOLOGY	20	RHEUM.	15	VASCULAR	15
GENL MED	8	TRIAGE	10		


AMOUNT OF CHANGE
+36
+32
+28
+24
+20
+16
+12
+8
+4
0
-4
-8
-12
-16
4
8
12
16
20
24
28
32
36
40
44
NUMBER OF PHYSICIANS


VERY FAVORABLE
extremely useful
35
30
25
FAVORABLE
useful
20
15
10
VERY UNFAVORABLE
almost useless
5
0
1970 DATA (N=73)
1969 DATA (N=47)
10 20 30 40 50 60 70 80 90 100
% OF PHYSICIANS
(CUMULATIVE)


% OF PHYSICIANS
25
20
15
10
5
0
5
10
15
20
25
30
35
40
VERY UNFAVORABLE
almost useless
FAVORABLE
useful
VERY FAVORABLE
extremely useful